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AUTHOR	Ferdous, Abdullah; Plake, Barbara
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ABSTRACT

In the Angoff standard setting procedure, subject matter experts (SMEs) estimate the probability that a hypothetical randomly selected minimally competent candidate will answer correctly each item comprising the test. In many cases, these item performance estimates are made twice, with information shared with SMEs between estimates. This estimation process can be time-consuming and fatiguing, especially for the SMEs. This study addressed the possibilities of saving time and resources in an Angoff standard setting study. The study used three sets of databases, two from a medical health certification program, with 10 judges for each data et, and one from a financial analyst certification study, with 33 judges. The study shows that using subsets of items, as opposed to the full length test, could be an important consideration that could reduce the time and resources necessary to conduct a standard setting study. The results of this study suggest that 50% of test items may be sufficient to estimate an equivalent minimum passing score in an Angoff setting study. This could result in a substantial saving of time and resources not only for the agency that has been carrying out this activity, but also to the practitioners (panelists) who participate in the standard setting study. (Author/SLD)

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Running Head: The Use of Subsets

The Use of Subsets of Test Questions in an Angoff Standard Setting Method

Abdullah Ferdous and Barbara Plake

University of Nebraska - Lincoln

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Abstract

In an Angoff standard setting procedure, subject matter experts (SMEs) estimate the probability that a hypothetical randomly selected minimally competent candidate (MCC) will answer correctly each item comprising the test. In many cases, these item performance estimates are made twice, with information shared with the SMEs between estimates. Especially for long tests this estimation process can be time consuming and fatiguing for the SMEs. This study addressed the possibilities of saving time and resources in an Angoff standard setting study. This study showed that using subsets of items as opposed to the full-length test could be an important consideration that could reduce the time and resources necessary to conduct a standard setting study. The results of this study suggest that 50 percent of test items may be sufficient to estimate an equivalent MPS in an Angoff setting study. This could result in a substantial saving of time and resources not only for the agency that has been carrying out this activity but also to the practitioners (panelists), who participate in the standard setting study.

The Use of Subsets of Test Questions in an Angoff Standard Setting Method

Background

The Angoff (1971) method is one of the most prominent and widely used test-centered standard setting procedures. In this method, a panel of judges is used to set minimum passing scores. These judges are considered to be experts in the content domain being assessed (Jaeger, 1991). The judges are asked to conceptualize a randomly drawn minimally competent candidate (MCC) and to estimate the probability that the MCC will correctly answer each of the items in the test. These item performance estimates are summed across the items in the test, to yield an individual judge's MPS. These individual MPSs are then averaged to estimate a recommended MPS.

In most cases, the recommended MPS is derived in number of iterations of the Angoff procedure; usually the number of iterations is two. In the first iteration, an initial estimate of MPS is derived; then the judges are provided with data either about candidate performance (p-values and/or impact data) or initial MPS values for the panel members (Reckase, 2001). In the second iteration, the judges are asked to re-estimate the proportions of MCCs who would answer each item correctly. Based on the judges' revised estimates, the recommended MPS is derived using the same procedures used in the first iteration. The second set of estimates are considered to be better informed and therefore lead to more defensible standards because many sources of error due to judges' misunderstanding, carelessness, inconsistencies, and mistakes are removed from their estimates (Hambleton, 1998).

Based on the above description of the Angoff method, it is evident that the recommended MPS is often based on two iterations based on the judges' estimates of the MCC's performance on each and every item in the test. If the recommended MPS could be estimated using a subset of

the test items as opposed to the full-length test, a saving in time and resources could be realized for the agency that has been carrying out this activity. Moreover, the judges who participate in this activity of setting a passing score are often practitioners in their profession who may have to miss business opportunities or close their offices when they participate in the standard setting study. Therefore, serving a longer time in the standard setting process not only costs the individual panelists but also the organizations they are associated with. However, it must be demonstrated that equivalent results would occur if only a subset of the full test was used in the standard setting study.

Few studies have been carried out concerning cost reduction in a standard setting study. A study done by Harvey and Way (1999) developed a web-based standard setting system to offset the costs of travel of the judges to a central location. The results of the study suggested that recommended MPS from an Internet study would be similar to those from a monitored on-site study. Sireci, Patelis, Rizavi, Dillingham, and Rodriguez (2000) showed that the MPS values derived using only two-thirds of the items composing a CAT item pool were very similar to cutscores from using the entire item bank. However, the study involved only a single panel of experts and evaluated the method using a single test.

The purpose of this study was to compare the MPS values estimated using a variety of subsets of items as opposed to the full-length test in certification examinations.

Methods

Data

This study used three sets of databases, two from a medical health certification program and one from a financial analyst certification program. Two separate standard setting studies were conducted for the medical health program, one in 1995 and the second in 2000. The

examination that was used in each of these studies consisted of 110 operational items, but there were no common items across these two examinations. In both studies, panels of 10 judges participated, but there were no common panelists across the two studies. The estimates of the MPS were obtained in two iterations of the Angoff standard setting method. Only the performance estimates provided on iteration two were used to calculate the estimated MPS values.

The financial analyst study was conducted in 2001 and consisted of a total of 230 items. A panel of 33 judges participated in the study. The panelists were randomly divided into two groups. The two panels (A and B) each looked at all 230 items in the test. The analysis from panel A was cross validated with the analysis from panel B. Estimates of the MPS were obtained in two iterations. The data from iteration two was used in this study.

Both agencies developed their tests based on tables of specifications designed to represent the content categories for their certification area. For the medical health examination there were a total of six categories. The financial analyst examination also had six content categories. Each content category was weighted by the agency based on its important to the respective certification decision. The proportion of items in each content category comprising each test was consistent with these weighting.

Formation of Subsets

Before forming the subsets, the test items were grouped into ten categories based on the difficulty level of the items. The items that had difficulty level of 0-0.10 constituted category 1, items with difficulty level of 0.11-0.20 was category 2, and items with difficulty level of 0.90-1.00 comprised category 10.

In this study, we extracted 5%, 10%, 20%, 30%, 40%, 50%, 60%, and 70% of the total items to constitute the subsets. To select the items from the full-length test, a stratified random sampling technique was used. The item difficulty level categories were used as the strata. Items were selected randomly proportionately to the total number of items in the full-length test that appeared in each of the ten strata. This same approach was used creating the sub-set of items for all four of the databases - two for medical health (1995 and 2000) and two for financial analyst (Panel A and Panel B data).

Data Analysis Plan

The MPS for the full-length tests (certification examinations for medical health and financial analyst) had been estimated through an Angoff method, in which the panelists' second set of item performance estimates were summed across the items in the test, then these individual MPSs were averaged to estimate an overall MPS. The MPS values for the subsets were estimated in the same way as MPSs for the full-length test had been estimated. These MPSs were compared for equivalence. For the medical health studies, the MPSs based on the eight subsets were compared to the MPSs of the full-length tests from the 1995 and 2000 standard setting studies, respectively. For the financial analyst study, the comparison of the eight MPS values to the full-length test MPS were determined for both panels, A & B, allowing for a cross validation of the results. The obtained MPSs for subtests and the full-length test then were compared using a one-way ANOVA to determine whether there were any statistically significant differences between the MPSs.

As a follow-up analysis, repeated samples were drawn for the relevant subsets to examine the pattern of the results. Finally, the same number of items in the relevant subsets of interest were also selected using a simple random sampling to examine whether the results obtained were

dependent on the item selection method. The purpose of these follow-up analyses was to provide substantive information relevant to the item selection technique.

Results

Medical Health Studies

The results from the Medical Health Study 1995 (Table 1) showed that the average difficulty level of the full-length test was 83. This was determined by summing the p-values of the items that comprised each of the tests. For sub-tests that were shorter than the full-length test, the average difficulties were found to be comparable to that from the full-length test. Using the subset of 50% items, the average difficulty level (82) differed only by 1-point from the average of the full-length test. However, a maximum difference of 3-points was found for the subsets of 5% and 10% items.

The average difficulty level of the full-length test for the Medical Health Study 2000 was 91 (Table 2). Using the subset of 40% and 50% items, the average difficulty level (90) differed only by 1-point from the average of the full-length test. The maximum difference of 3-points was found for the subset of 5% items.

The Medical Health Study 1995 and 2000 showed that the MPSs using the full-length test were 72 and 86 respectively (Table 1 and Table 2). These same MPS values were also obtained when using 40% and 50% of test items in the respective studies. For both sets of (1995 and 2000) data, the remaining subsets that contain of 5%, 10%, and 30% of items, produced an MPS estimate that had a maximum difference of 3-points, however. None of the estimates were found to be statistically significant ($p > 0.05$). The standard error of measurement was also calculated for both the data sets to assess the stability of the estimated MPSs. They were found to be 2.40 for Medical Health 1995 and 1.33 for 2000. To be more conservative, we lowered it to the

nearest integer values, i.e., 2 for 1995 and 1 for 2000 Medical Health study. The estimates of MPS for both studies obtained using 50% of items fell within the one SEM of the MPSs of the full-length tests.

Financial Analyst Study

The results from panel A, Financial Analyst Study 2001 showed that the average difficulty level of the full-length test was 144, which was also obtained from the subsets of 30%, 40%, 50%, 60% and 70% items. The maximum difference of 7-points was found for the subset of 5% items (Table 3).

The average difficulty level of the full-length test for panel B, Financial Analyst Study 2001 was 144 (Table 4). Using the subset of 50% items, the average difficulty level (145) differed only by 1-point from the average of the full-length test. The maximum difference of 7-points was obtained for the subset of 5% items. With subsets of 20%, 30%, 40%, 60% and 70% items, the average difficulty level were exactly the same as it was for the full-length test.

The results for the Financial Analyst study 2001 for panel A and panel B (Table 3 and Table 4) showed that the MPSs using the full-length test were 157 and 143 respectively. Using 50% of the test items, the respective panels' estimated MPS values were 157 for panel A and 145 for panel B, which were zero points and 2-points apart from the MPSs of full-length tests respectively. The estimates obtained from the remaining subsets (5%, 10%, 20%, 30%, and 40% of test items) for panel A and B, had maximum difference of 27-points and 5-points from the MPSs of full-length test, respectively. However, the estimated MPS for the 5% of items for Panel A only, was found to be statistically significant ($p>0.05$). The standard errors of measurement were found to be 3.69 for panel A and 3.28 for panel B. If these were lowered to the nearest

integers, the SEM was 3 both for panels. The estimated MPSs using 50% of test items for both the panels were within one SEM of the MPSs of the full-length test.

Follow-up Analysis

The estimated MPS values and the average difficulty level based on the stratified random sampling of 50% of the test questions yielded promising results for both the Medical Health and Financial Analyst analyses. These values were systematically equal or at most one point from the full-length test MPS values. As a follow up analysis, two repeated stratified samples of 50% were generated to examine the stability of the results. For the Medical Health 1995 data, the two repeated stratified samples had average difficulty level of 82, which was within 1-point difference from the average of the full-length test (83) and yielded MPS estimates of 71 and 72 compared to 72 for the full-length test (Table 5). For the 2000 data, both repeated stratified samples resulted in estimated MPSs of 85 compared to 86 from the full-length test and had an average difficulty level of 90, which was within 1-point from the average of the full-length test (Table 5). For Financial Analyst data, the repeated stratified random samples of 50% items had an average difficulty level of 145 for panel A, and 144 and 145 for panel B, which were within 1-point of the average of the full-length test and resulted in estimated MPS values that were no more than 1-point different from the full-length test MPS values (Table 6). Therefore, all the estimated MPSs using 50% of test items were found to have no statistical significant difference ($p > 0.05$) and were statistically equivalent to the MPS using the full-length test.

As the estimated MPS values based on the stratified random sampling of 50% of the test questions generated a systematic and stable results, our next concern was to examine whether these stable results were due to the any particular item selection methods. Therefore, a sample of 50% items was drawn using a simple random sampling method from each of the data sets.

The estimates of the MPSs obtained from the 50% random samples had maximum difference of 7-points from the respective MPS of the full-length tests. Medical Health 1995 data resulted in estimated an MPS of 72 (compared to 72 from the full-length test) and the 2000 Medical Health data yielded MPS estimates of 84 (compared to 86 for the full-length test) (Table 5). However, the average difficulty level of the random samples differed by 1-point and 4-points from the average difficulty level of the full-length tests 1995 and 2000 respectively (Table 5). For the Financial Analyst data, the estimated MPS values for panel A and B are 164 (compared to 157 from full-length test) and 148 (compared to 143 from full-length test) respectively (Table 5). For Panel A and B, the average difficulty level of the random samples differed by 3-points and 2-points from the average difficulty level of the full-length test, respectively (Table 6).

Discussion

This study addressed the possibilities of saving time and resources in an Angoff standard setting study. This study showed that using subsets of items as opposed to the full-length test could be an important consideration that could reduce the time and resources necessary to conduct a standard setting study. Reducing the number of items would result in savings of time and resources when conducting a standard setting activity, in particular during ratings of the items in each round (in the case of a multiple round standard setting study), disseminating feedback data, and entering data between rounds. Moreover, the judges who participate in this activity of setting passing scores are often practitioners in their profession who may have to miss business opportunities or close their offices when they participate in the standard setting study. Therefore, serving a longer time in the standard setting process not only costs the individual panelists but also the organizations they are associated with. The results of this study suggest that a stratified random sample of 50 percent of test items may be sufficient to estimate an

equivalent MPS in an Angoff setting study. This could result in a substantial saving of time and resources not only for the agency that has been carrying out this activity but also to the practitioners (panelists), who participate in the standard setting study.

It is important to keep in mind when interpreting the results that the test items in the subsets were selected based on the actual difficulty level of the items, and proportionately to the total number of items within the pre-specified item difficulty-level categories. Another important point to consider is that a stratified random sampling technique was used for selecting the items in the subsets. The result of the study was found to be sensitive to the item selection methods (i.e., to the stratified random sampling method). The study used a simple random sampling method an alternative to the stratified random selection method to examine the sensitivity of the results. These estimates were found to be unstable and barely equivalent to the MPS for the full-length test.

Sireci, et al. (2000) carried out a study on a standard setting methodology with computer adaptive tests. The study indicated that MPS derived using only two-thirds of the items composing a CAT item pool were very similar to MPS derived using the entire item bank. However, the study involved only a single panel of experts and evaluated the method using a single test. This study yields much stronger results compared to the study conducted by Sireci, et al. (2000) because only one half of the test items were needed to reach equivalence. Moreover, this study used multiple data sources to examine the stability of the results across different subject areas and occasions. Therefore, the results may be generalized within and across different content areas.

The results of this study were limited due to the fact that the classifications of actual items within the table of specification were not available. Therefore, only a one-stage stratified

random sampling was used to select the test items for the subsets; using only item difficulty level categories as the strata. We know that the precision of the estimate is a function of number of strata, i.e. more strata results in more precise estimates. Therefore, if item classification by the table of specification were available, then a two-stage stratified sampling method could have been used to examine the precision of the estimates. Such a strategy may have resulted in the use of even less than 50% of the items to yield equivalent results to that from the full-length test.

Future research should focus on examining of the generalizability of these results and the conditions that supported the close proximity of the MPS values for the 50% subsets to the full-length tests. More research should be done on investigating the sensitivity of the results to test item selection techniques. There are other factors, specific to the particular standard setting situations that could reduce time and resources both for agencies conducting this activity and the panelists who are participating this activity. These should be researched along with the effects of reducing test items.

The purpose for a standard setting study is to make the most accurate and defensible prediction of a minimum passing score possible. Important decisions are made based on these passing scores. No decision should be made based on these passing scores that are unfair to the candidates' future. These decisions can influence the candidates' livelihoods, especially in the licensure and credentialing field. A great deal of time and money is spent on the process of setting these passing scores. One initiative for this study is to save time and resources but not at the cost of setting inaccurate passing scores and doing injustice to the candidates' future. So, if a justifiable, defensible, and an accurate passing score can be set while still reducing time and resources, this would be a highly desirable outcome. The need to address the issues of reducing time and resources both for the agencies and panelists in a standard setting study is of great

importance. The results of this study suggest that may be feasible to set the passing scores with the Angoff method using a subset of items from the full-length test.

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Table 1

Comparison of the Minimum Passing Scores: The Medical Health Study, 1995

	No. of items	Estimated MPS	Absolute difference
Full-length test	110	72 (83)	
Percentage of total test-items in the subsets			
5%	6	75 (86)	3 (3)
10%	11	74 (86)	2 (3)
20%	21	73 (84)	1 (1)
30%	34	70 (82)	2 (1)
40%	44	72 (83)	0 (0)
50%	55	73 (82)	1 (1)
60%	66	72 (83)	0 (0)
70%	78	72 (83)	0 (0)

Note. Numbers in parentheses are the sum of p-values and their absolute differences due to sampling. None of the minimum passing scores (MPS) are statistically different from the MPS of the full-length test at $p = 0.05$.

Table 2.

Comparison of the Minimum Passing Scores: The Medical Health Study, 2000

	No. of items	Estimated MPS	Absolute difference
Full-length test	110	86 (91)	
Percentage of total test-items in the subsets			
5%	6	89 ((4)	3 (3)
10%	11	84 (90)	2 (1)
20%	21	85 (90)	1 (1)
30%	34	87 (91)	1 (0)
40%	44	86 (90)	0 (1)
50%	55	86 (90)	0 (1)
60%	66	86 (90)	0 (1)
70%	78	86 (91)	0 (0)

Note. Numbers in parentheses are the sum of p-values and their absolute differences due to sampling. None of the minimum passing scores (MPS) are statistically different from the MPS of the full-length test at $p = 0.05$.

Table 3.

Comparison of the Minimum Passing Scores: Panel A, the Financial Analyst Study, 2001

	No. of items	Estimated MPS	Absolute difference
Full-length test	230	157 (144)	
Percentage of total test-items in the subsets			
5%	11	184 (151)	27* (7)
10%	22	162 (141)	5 (3)
20%	47	164 (144)	7 (0)
30%	69	158 (144)	1 (0)
40%	92	160 (144)	3 (0)
50%	115	157 (144)	0 (0)
60%	138	156 (144)	1 (0)
70%	162	157 (144)	0 (0)

Note. Numbers in parentheses are the sum of p-values and their absolute differences due to sampling. Minimum passing scores (MPS) obtained from the subset with 5% of items is statistically different from the MPS of the full-length test at $p = 0.05$.

Table 4.

Comparison of the Minimum Passing Scores: Panel B, the Financial Analyst Study, 2001

	No. of items	Estimated MPS	Absolute difference
Full-length test	230	143 (144)	
Percentage of total test-items in the subsets			
5%	11	145 (151)	2 (7)
10%	22	148 (142)	5 (2)
20%	47	139 (144)	4 (0)
30%	69	145 (144)	2 (0)
40%	92	143 (144)	0 (0)
50%	115	145 (145)	2 (1)
60%	138	145 (143)	2 (1)
70%	162	143 (144)	0 (0)

Note. Numbers in parentheses are the sum of p-values and their absolute differences due to sampling. None of the minimum passing scores (MPS) are statistically different from the MPS of the full-length test at $p = 0.05$.

Table 5.

Comparison of the Minimum Passing Scores with Repeated Samples: The Medical Health Studies, 1995 and 2000

	No. of items	Estimated MPS	Absolute difference
Medical Health, 1995 (full-length test)	110	72 (83)	-
Stratified Random Samples			
Subset with 50% items	55	73 (82)	1 (1)
Repeated sample 1	55	71 (82)	1 (1)
Repeated sample 2	55	72 (82)	0 (1)
Simple random sample	55	72 (82)	0 (1)
Medical Health, 2000 (full-length test)	110	86 (91)	-
Stratified Random Samples			
Subset with 50% items	55	86 (90)	0 (1)
Repeated sample 1	55	85 (90)	1 (1)
Repeated sample 2	55	85 (90)	1 (1)
Simple random sample	55	84 (87)	2 (4)

Note. Numbers in the parentheses are the sum of p-values and their absolute differences due to the sampling.

Table 6.

Comparison of the Minimum Passing Scores with Repeated Samples: The Financial Analyst Study, 2001

	No. of items	Estimated MPS	Absolute difference
Financial Analyst			
Panel A (full-length test)	230	157 (144)	-
Stratified Random Samples			
Subset with 50% items	115	157 (144)	0 (0)
Repeated sample 1	115	158 (145)	1 (1)
Repeated sample 2	115	157 (145)	0 (1)
Simple random sample	115	164 (147)	7 (3)
Panel B (full-length test)	230	143 (144)	-
Stratified Random Samples			
Subset with 50% items	115	145 (145)	2 (1)
Repeated sample 1	115	144 (144)	1 (0)
Repeated sample 2	115	142 (145)	1 (1)
Simple random sample	115	148 (146)	5 (2)

Note. Numbers in the parentheses are the sum of p-values and their absolute differences due to the sampling.

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